

thickness of $5\frac{1}{8}$ inches of the light silicate crown absorbs only 20 per cent. of candle light.

These figures must be regarded as preliminary. I intend to check the results and present them in a more accurate and digested form on a future occasion. But as far as they go these results are surprising as showing what an improvement has taken place in the transparency of glasses (a few blocks of ordinary crown and flint glasses were also tried and found nearly as transparent as the block of 0.374) within the last few years, when thicknesses of four inches only were generally found to absorb as much as one half of the light.

Thus this triple objective might be made in very large sizes, 2 feet aperture or so, before the loss of light due to thickness would become so great as to put it on an equality as regards light-gathering power with a Newtonian reflector of average condition and similar aperture.

Buckingham Works, York.

Brilliant Detonating Fireball of 1894 January 25.

By W. F. Denning.

A very murky condition of sky, with occasional rain, appears to have prevailed over a considerable part of England on the night of 1894 January 25, and the only celestial objects visible were *Jupiter* and two or three of the brighter stars shining very dimly through the clouds. At about 10^h 1^m, in the Midland Counties, the dark atmosphere was instantaneously illuminated with a light perfectly dazzling in its intensity, and people who noticed it thought for a moment that the full Moon had suddenly come into view. On glancing upwards, however, they immediately detected the real cause in the form of a large pear-shaped fireball rolling across the sky from the direction (as observed at many places) of N.W. to S.E., and scattering behind it a bright tail of sparks. Those who obtained the most complete view of the object describe it as small at first, like an ordinary shooting star, but, after traversing about one-third of its course, it appears to have suddenly burst out into a startling size and brightness, and afterwards divided into two parts. As it disappeared the section of its track following the nucleus was beaded with fragments decreasing in size from the foremost. The colour of the latter was variously described as blue and green, and several observers compare it with the electric light; the tail and hinder parts of the nucleus appear to have been yellow merging into red. From one to four minutes after the meteor had disappeared alarming detonations were heard at Worcester, Droitwich, Birmingham, Alvechurch, Malvern, Ross, Stroud, Cheltenham, and numerous other places in the same

district. Houses were shaken, windows and furniture were rattled violently, and there was a perceptible vibration which many people quite naturally mistook for an earthquake shock.

I have collected about forty-five descriptions of the fireball, and though the majority of these are merely of a popular character, containing few details useful for scientific purposes, there are several by astronomical observers, and these enable a satisfactory path to be derived. It may be interesting to quote from some of the best accounts:—

Clapham, near Lancaster.—Very brilliant meteor seen at 10^h 5^m, January 25. The sky was covered with light clouds, so that only the larger stars could be seen through the film. When first observed the meteor was near the *Pleiades*, its course being close to the belt of *Orion*, and it disappeared in the neighbourhood of η *Canis Majoris*. Duration six seconds.—*T. R. Clapham*.

King's Heath, Birmingham.—At 10^h 3^m, the sky being so hazy that only *Jupiter* and one or two stars were visible, a brilliant light suddenly appeared in the N.W. sky. On looking up a fireball of extraordinary brilliancy was perceived. Its motion was remarkably slow, and a train of great length followed in its wake. It traversed an arc of 120°, passing between *Jupiter* and the *Pleiades* and breaking up near *Rigel*. The nucleus was a brilliant bluish white colour, and its motion was uneven, as though the body encountered impediments in its flight through the atmosphere. The meteor sent out a distinct hissing sound during a considerable part of its passage. The end point was very fairly determined, for the moment after the meteor had expired *Rigel* appeared to view, and gave the transient impression of being a portion of the nucleus that had suddenly become stationary. The duration of the whole apparition was twelve seconds. About three minutes after the meteor burst the report came: it resembled the “boom” of distant artillery. The report was distinctly a double one, followed by a dull reverberation that resounded from all parts of the sky.—*D. E. Packer*.

Edgbaston, Birmingham.—At 10^h 1^m a detonating meteor equal in size to a half-moon was seen. The sky was overcast, only the planet *Jupiter* being dimly visible, but the meteor illuminated the country like bright moonlight. At the end of its flight the nucleus burst, showering down fragments. An audible sound was heard at 10^h 4^m 5^s, resembling the subdued report from a piece of ordnance. The colour of the forward part of the nucleus was electric blue, the rest red; duration of flight 12 seconds. Path from Az. 15° W. of N., alt. 20°, to Az. 30° W. of S., alt. 25°.—*W. H. Wood*.

Sunderland.—Bright meteor, = 4, and apparently directed from the place of that planet, disappeared behind a house at a

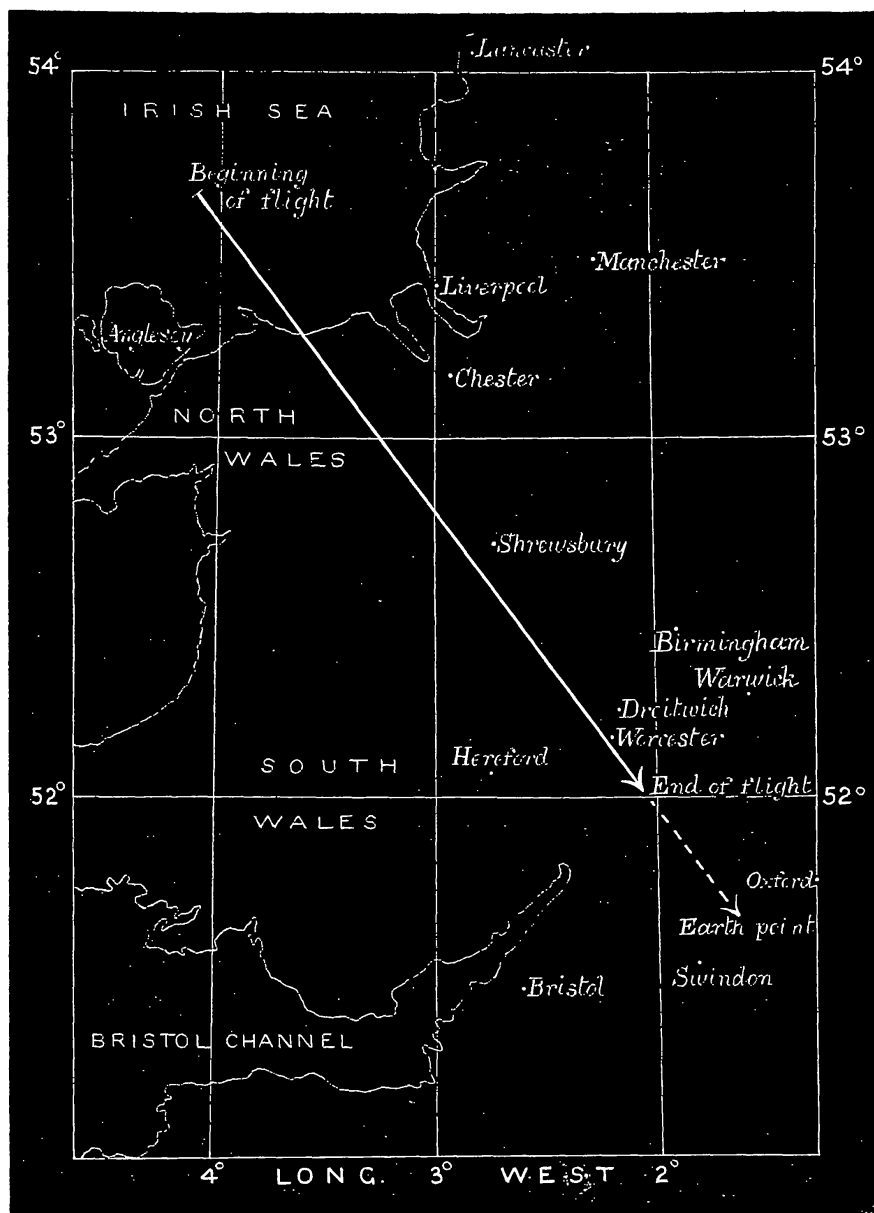
position occupied on February 2 at $9^h 27^m$ by $75^\circ - 25^\circ$. Course seen about 7° . Very slow, 1.2 second; colour green. Seen imperfectly through clouds.—*T. W. Backhouse.*

Bristol.—At $10^h 1^m$ a sudden and great brightening of the sky caused the observer to look upward, and the fireball was well seen during the last ten degrees of its course. The position was determined as from $242^\circ + 59^\circ$ to $229^\circ + 53^\circ$, and this may be considered pretty correct as to direction, though to include the whole visible path the line of flight must be extended back to about η *Cephei*. The place of the end-point corresponds approximately with Az. 26° E. of N., alt. 20° , and from several careful descriptions by other observers at Bristol the beginning occurred at Az. 22° W. of N., alt. 26° . Ten degrees from the point of its extinction the fireball consisted of a double nucleus, the foremost of the two parts being largest and brightest. Near the end these subdivided and formed a string of particles, when the whole phenomenon collapsed, and the sky resumed its previous darkness. The estimated duration was five seconds from the time of the first outburst of light, but the 10° of the observed path occupied less than two seconds.—*W. F. D.*

The other accounts need not be particularly referred to, as for the most part they simply describe the astonishing brilliancy of the meteor and its rough position. An observer at Henbury says it made a hissing noise as it passed, thus confirming Mr. Packer's impression.

As to the detonation that followed the meteor's disruption, this appears to have varied according to locality. Mr. W. H. Lloyd, of Stroud, describes it as a series of explosions (apparently from the N.E.) which sounded like a number of fieldpieces fired in rapid succession, followed by a volley of musketry. Mr. J. T. Southall, of Ross, Hereford, says a loud rumbling noise like an explosion was heard. It lasted two or three seconds, and two slight shocks, supposed to be due to an earthquake, were experienced. At Worcester the path of the meteor was from N.W., and shortly after its disappearance three detonations were heard, the last being of exceptional violence, shaking buildings and causing the earth to vibrate. At Droitwich it was supposed the Evesham Gas Works, twelve miles distant S.E., had blown up. At Alvechurch a detonation was heard similar to a clap of thunder. At Malvern, at $10^h 3^m$, a meteor of extraordinary size and brilliancy came from a N.W. direction, and three minutes after its disappearance a heavy rumbling noise was heard, immediately followed by the sound of a tremendous explosion. Mr. W. E. Clarke, of Elkstone (between Cheltenham and Cirencester), says he heard several explosions, and these seemed to come right from the opposite direction to the meteor's flight, and about ten or fifteen seconds after its disappearance. He refers to a peculiar "whirring" noise which followed the detonations, and says the nearest resemblance to it he can suggest is "the sound

made by rapidly swinging round and round a piece of tin attached to the end of a string."



Path of Detonating Fireball, 1894 January, 25^d 10^h 1^m.

I have compared the various observations of the apparent path, and find there is a tolerably good agreement amongst them. The following are the resulting positions and heights:—

Observed beginning of flight over a point in lat. $53^{\circ} 42' N.$, long. $4^{\circ} 7' W.$ (24 miles N.N.E. of Amlwch, Anglesey); height 89 miles.

Observed ending of flight over lat. $52^{\circ} 2' N.$, long. $2^{\circ} 5' W.$ (Ashchurch, Tewkesbury); height 16 miles.

March 1894.

Fireball of 1894 January 25.

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Earth point in lat. $51^{\circ} 42'$ N., long. $1^{\circ} 42'$ W. (Lechlade, on the eastern border of Gloucestershire).

Real length of observed path = 160 miles.

Duration of flight (mean of twelve estimates) = 9 seconds.

Velocity 18 miles per second.

Radiant point $331^{\circ} + 55^{\circ}$, near ϵ *Cephei*.

The meteor passed almost vertically over Shrewsbury and Worcester, at elevations of 45 and 22 miles respectively.

The observed beginning is that noted by Mr. Clapham, whose position was 22 miles N.E. of Lancaster. Possibly the fireball may have acquired visible incandescence much earlier than this in its flight, and when it was passing over the Isle of Man, but we have no positive evidence on this point. Nearly all the observations cluster round the counties of Warwick, Worcester, Hereford, and Gloucester, and there is a singular lack of accounts from North Wales and the northern parts of England. The cloudy state of the sky at the time is no doubt in a great measure responsible for this. There is, it is true, one report from Mold, North Wales, where the meteor appears to have looked larger than the Moon, but no particulars are given as to the path.

The height at end is well indicated by the King's Heath (Birmingham) and Bristol observation. It agrees also with the interval between the explosion and detonation, as recorded at Birmingham and some other places. Mr. Packer, at King's Heath, puts the interval at 3 minutes, while Mr. Wood, at Birmingham, estimated it as 3 minutes 4 seconds. The meteor was 36 miles distant from Birmingham at the end point, and sound, travelling at the rate of 1,090 feet per second, would occupy 3 minutes in traversing 37 miles. The agreement is not so precise when the same comparison is applied to certain other stations, but it must be remembered that the time intervals were in nearly every case little better than mere guesses, and not well-determined periods. Moreover, the detonation may not have been caused by the disruption of the meteor precisely at the place of its extinction, for disintegration had been obviously going on some time before. Several of the accounts would appear to suggest that one of the explosions must have occurred when the meteoric *débris* had gone a few miles beyond the place of its disappearance in a prominently luminous state.

It is evident that distance had a great effect upon the apparent brightness of the object. At Sunderland the observer estimated it as equal to *Jupiter*, but his position was about 175 miles from the section of the meteor's path, S.E. of Shrewsbury, which he observed. At Clapham, Lancaster, the distance from the meteor was also considerable, varying from 120 to 157 miles, and here the light was thought to equal *Venus*. But at Worcester, where the minimum distance was only 22 miles, the meteor illuminated the sky with an effect exceeding that of the full Moon, and it was compared to that of the great electric search-light by several observers.

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The duration of the meteor's flight was variously estimated at from 1 or 2 seconds to 1 or 2 minutes. A mean of twelve of the most reliable accounts gives 9 seconds, and from this I derive the velocity as 18 miles per second. Atmospheric resistance no doubt had the effect of considerably moderating the native speed of the meteor.

The radiant point at $331^{\circ} + 55^{\circ}$ near ϵ *Cephei* is rather a novel one for the season, and I believe the only January shower of Cepheids hitherto observed is that seen at $329^{\circ} + 60^{\circ}$, 1886 January 4-8, by the writer at Bristol. In the summer and autumnal months there are many radiants in this region of *Cepheus*, and the position represents one of the apparently long-enduring, fixed showers which are so difficult of explanation (see *Monthly Notices*, vol. l. pp. 416 and 467).

The great detonating fireball seen in the north of England on the morning of 1879 February 24 had a radiant approximately determined at $310^{\circ} + 55^{\circ}$, and suspiciously near that of the similar fireball of January 25 last.

It is, perhaps, a little questionable whether large fireballs of the detonating class are always indicative of ordinary meteor showers, as they often appear in an isolated manner and are frequently directed from radiants situated in the vicinity of the horizon and in the western half of the sky. Slowness of motion is also a characteristic feature of these bodies. After seeing one of them an observer may watch the heavens during the remaining part of the night and note many meteors without detecting one from the fireball radiant. This has sometimes been my own experience, and there seems little reason to doubt the comparative exclusiveness of such phenomena. But of course if observations were undertaken on a wider basis, and many observers participated in them, the solitary nature of these bodies might not be confirmed. It is one of those features on which we cannot speak with certainty owing to the inadequacy of past observation. But in whatever light we regard these brilliant slow-moving fireballs it is certain they form the most interesting and attractive type of meteoric apparitions.

Bristol:
1894 February 4.

Erratum in Col. Markwick's paper. ("Monthly Notices," vol. liv. No. 3.)

In the diagram on page 139 of the "Light Curve of W Sagittarii" the numbers denoting the brightness should be shifted upwards one line, so that the top line reads 4.8 and the lowest line 5.8.